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Application Note

PV Safety

SolarEdge Technologies

Solar photovoltaic (PV) installations are gaining more and more popularity and their benefits and upsides are well acknowledged. However, safety concerns have accompanied photovoltaic installations from the start. Although codes and standards were devised over the years to improve system safety, several issues persist, dominated by the danger of electric voltage, which might cause:

- Electrocution at time of installation or during maintenance
- Risk to firefighters during a fire
- Arc generation that can start a fire or cause electrocution

SolarEdge adopted a holistic viewpoint of the PV industry aiming at maximizing energy harvesting while minimizing cost and safety risks. The SolarEdge distributed power harvesting architecture contributes to the higher safety of the PV system automatically, without the need for any manual procedure and at no added cost.
In the following article we will elaborate on the risks of PV systems, the SolarEdge solution and the way this solution contributes to prevention of electric voltage risks and other problems associated with PV system security, such as theft and decreased yield.

PV System Risks

Whenever a PV module is exposed to light, it immediately produces DC voltage. This voltage may turn fatal in the following incidents:

- **Electrocution risk at time of installation or during maintenance.** Every series connection of several modules exposed to sunlight generates a voltage high enough to kill a person touching the exposed contacts (in the US a safe outdoors DC voltage is 30V , therefore just one or two active modules create a dangerous voltage, or 3-4 with low-voltage modules; in Europe a safe outdoors voltage is 120V , therefore 3-4 active modules create a dangerous voltage, or over a dozen with low-voltage modules). For this reason work procedures and safety precautions are employed during installation, slowing the process. The high voltages remain even if the inverter is disconnected from the modules or from the AC grid, making the risk relevant also post-installation, when maintenance work takes place.

■ **Risk to firefighters during a fire.** One of the safety measures firefighters take when dealing with a building fire is cutting power to the building. This enables them to spray water and use axes to cut holes in the roof to let smoke out. After power to the building is cut the firefighters assume there is no power source endangering them. If the building has a photovoltaic installation, this assumption is false. Firefighters preparing to chop a hole in the roof or use water can be electrocuted. Regulatory bodies, firefighting officials and industry members are pushing for new regulations that will ensure module shutdown in case of a fire.

■ **Arc generation.** Due to the high DC voltage, any disconnection or faulty connection in a current-carrying wire can cause an arc, which is the continuation of current flow through the air. This generates a lot of heat which in turn can cause a fire. Additionally this poses further danger of electrocution. Large PV installations may have thousands of contacts, each one a potential arc generator, especially when exposed to natural forces, rodents, cable swinging, or human errors at installation.

The SolarEdge Solution

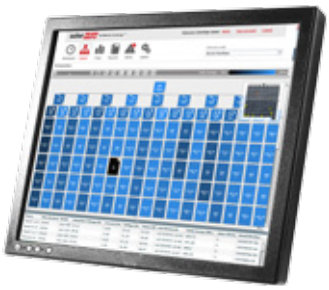
PV is still a relatively new technology and most installations are only several years old. As the systems age, wiring and contacts deteriorate, increasing the chances of arcs, electrocution and other fire risks, in addition to posing a risk in the case of an unrelated fire. Since the number of PV installations is expected to grow, fires in structures that have PV installations are estimated to occur more frequently.
Therefore the safety issues must be addressed today – and that is what SolarEdge does. SolarEdge systems have a built-in safety feature that eliminates the safety risks, and can save lives.
The SolarEdge distributed power harvesting and monitoring system is composed of three elements:

■ SolarEdge Power Optimizer:

The SolarEdge power optimizer is integrated into each module, replacing the traditional junction box, or connected to it externally. The power optimizer optimizes energy output by performing MPPT for each module, and enables monitoring of each individual module. Further, each string's power optimizers automatically maintain a fixed string voltage, giving installers greater flexibility to design optimal PV systems.

■ SolarEdge Inverter:

The SolarEdge inverter is a highly reliable inverter. Because MPPT and voltage management are handled separately for each module, the inverter is only responsible for DC to AC inversion. Consequently, it is a simpler, more reliable device. The fixed string voltage ensures operation at the highest efficiency at all times, independent of string length and temperature.



■ SolarEdge Monitoring:

A web-based software that provides module-level, string-level and system-wide performance monitoring. The software automatically provides alerts on a wide range of issues affecting energy generation and system safety that might otherwise go undetected, guides the user through a semi-automatic troubleshooting process, and can pinpoint the location of underperforming modules onto a PV site map.

SolarEdge Built-in Safety Package

The module-integrated power optimizers are the built-in safety enhancers of the SolarEdge system. These field-proven features inherently minimize safety risks, with no added hardware, no manual operation and therefore at no added cost.

Electrocution Prevention

- **Safe installation:**

Modules with embedded power optimizers start up in "Safety Mode" when exposed to light. In this mode the SolarEdge power optimizers ensure each module outputs as little as 1 volt, so the string DC voltage remains safe. Only when a SolarEdge inverter is connected to the strings and switched on, the modules start producing energy, and the string DC voltage increases. Consequently, installers face no risk of electrocution, because no dangerous voltage occurs until the system is fully installed.

- **Safe maintenance and firefighting:**

In the event of a grid power shutdown, the solar modules immediately stop producing power and revert to the "Safety Mode". This is beneficial to firefighters and to PV maintenance personnel working at the site. They need not worry about high DC voltages; once AC power is cut, all voltage shuts down and the roof is safe.

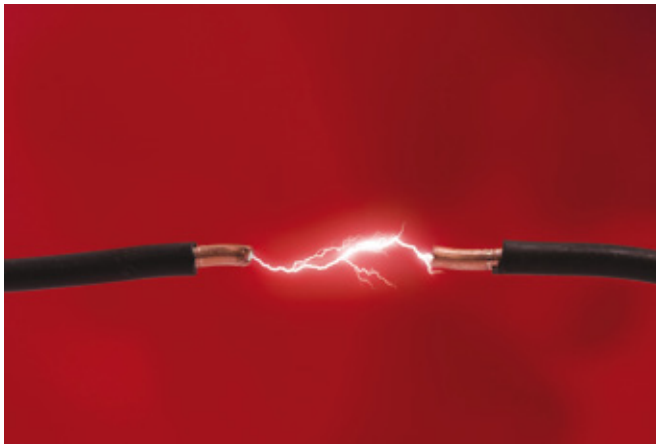
- **Thermal shut down:** As a further precaution, necessitated by the occasional inability to cut AC power to the site (e.g. due to unknown switch location, switch is source of fire), modules and inverter shut down when a certain temperature is exceeded, eliminating the need for special procedures before tackling a fire.

[i] The current standard for system safety in the US is NEC (National Electric Code) 2008; modules and inverters must conform to UL1741 and UL1703

[ii] UL1741 clause 11.1.2, Table 11.1

[iii] IEC62103 clause 5.2.3

[iv] Such as the UL1699 PV AFCI Ad Hoc Working Group, with representatives of regulatory bodies and system manufacturers



Arc Protection

SolarEdge power optimizers can automatically detect and prevent arcs by sensing their unique electric characteristics as they occur. Once a power optimizer detects an arc it automatically shuts the module down, effectively terminating the arc and preventing its re-occurrence. Multiple detection by several power optimizers increases sensitivity and provides system owners with a reliable built-in fire prevention solution*.

In addition, the SolarEdge system offers solutions to other problems associated with the security of PV installations:

Theft Control

The SolarEdge system continuously monitors module performance and string connectivity, providing real-time alerts of any installation tampering, so theft attempts can be detected as they occur. As another layer of deterrence, in case of theft, the embedded power optimizer can digitally lock or "immobilize" stolen modules to ensure they cannot be re-used by the thief.

Yield Assurance

The SolarEdge monitoring system continuously tracks module power and status. This ensures quick detection of any deviation from expected energy yield. The cause can be immediately located and the situation rectified, delivering maximum system uptime and energy yield.

About SolarEdge

SolarEdge provides next generation power conversion electronics that effectively remove all known system constraints across the photovoltaic energy space. Our Smart DC technology enables increased production of clean, grid-ready energy and faster return on investment.

The SolarEdge technology marries traditional photovoltaic workflows and installation methods with a groundbreaking holistic system approach. It is a quiet revolution that is disruptive because of its profound benefits in changing the manner in which energy is harvested, deployed, managed and delivered and at the same time complementary because it fits into the current photovoltaic workflow.

At SolarEdge we believe the PV delivery chain is ultimately only as strong as its weakest link. By adopting a “system first” philosophy that identifies and eliminates the Achilles heel in each step in the process, we enable a constraint-free delivery of sun harvested energy.

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